teaching for understanding

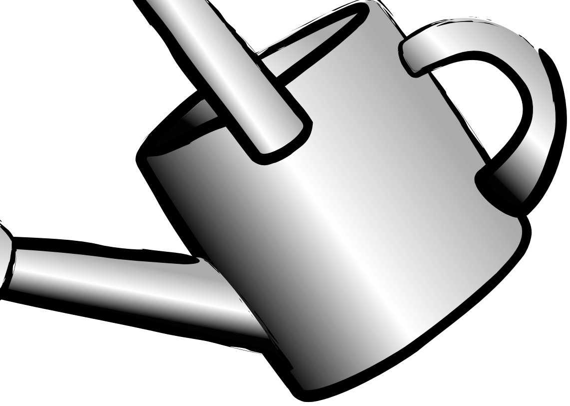

Understanding is not just about coverage of knowledge … but about **"uncoverage"**—being introduced to **new ideas** and being asked to **think** more **deeply** and more **carefully** about facts, ideas, experiences, and **theories** previously encountered and learned.

—*Grant Wiggins*

By Tom Sherman and Barbara Kurshan

Subject: Pedagogy, metacognition

Standards: *NETS•S* 3; *NETS•T* II; *NETS•A* II (http://www.iste.org/standards/)



A main **challenge** for teachers is to use these preconceptions as the **foundation** for helping learners **expand** or **modify** their existing **understandings**.

Wiggins' view of understanding requires students to integrate facts, information, knowledge, and applications to develop understanding. Understanding, from this perspective, is an extensive web of interrelated ideas, experiences, and beliefs that transforms information from simple, memorized facts into knowledge that can be the basis for action. Recent research and theory have provided a relatively clear picture of how technologies can support classroom teaching and learning that leads to this genuine understanding. Moreover, teaching for understanding appears to result in students passing or scoring higher on high stakes tests.

Over the past 8–10 years scientists, teachers, and behavioral investigators have synthesized research and practice to explain how to develop the intellectual tools and learning strategies needed to acquire the knowledge that allows people to think productively. These scientists believe that learners construct their knowledge from their experiences, a perspective that generates many implications for how to teach students to understand.

Psychologist John Bransford and his colleagues propose three strongly supported findings that capture the essence of this evidence for teaching and learning:

1. Preconceptions influence all learning.
2. Understanding comes from knowing facts and principles.
3. Metacognition is essential for understanding.

Teachers and learners can use technology in many ways to support these findings on human learning. Technology can help teachers discover students' preconceptions and provide a broad range of instructional options to meet diverse learner needs. Technology is a tool for teachers to more effectively and accurately create profiles of each learner's experiences and background and how students learn and then develop technology-based instruction consistent with each student's needs. For learners, technologies can open alternatives to mastering ideas, concepts, processes, and outcomes. Learners can employ technology to expose misconceptions, simulate solution applications, test facts, and respond to problem-solving challenges. Integrating technology into instructional practices often improves student achievement; presents relevant, timely, and appropriate remediation; and provides content that can be crafted to meet different learning styles. We examine specific ways that technologies can contribute to meeting the findings of modern learning psychology.

Preconceptions Influence All Learning

Students come to school with well-formed ideas about how the world works. Called preconceptions, existing ideas that children hold are central to constructing new learning. Humans begin learning right from birth, and even very young children form ideas about their worlds based on observations and experiences. These preconceptions have powerful and enduring effects on how children learn new information as well as how they will remember and use new knowledge.

A main challenge for teachers is to use these preconceptions as the foundation for helping learners expand or modify their existing understandings. Another challenge is to correct misconceptions. Until recently, the impact of misconceptions has not been well understood, and they were generally thought to be easily corrected. However, most misconceptions are relatively firmly held beliefs based on observations of natural events and have practical explanatory power or are effective in limited applications.

For example, a flat earth theory is intuitive because the earth looks flat and we have no experience that contradicts the idea of a flat earth. And, a flat earth conception works very well with most experiences we have, for instance, building a small house. However, flat earth thinking becomes problematic for long-range navigation, as well as understanding geography and other sciences. It is not unusual for people to operate cognitively from a flat earth theory even though they know intellectually that the earth is not flat.

Classroom instruction is rarely designed to correct students' incorrect assumptions. Generally, the instructional approach is to teach the correct answer and problem-solving strategy. Misconceptions cannot be ignored because new and accurate information inconsistent with these miscon-

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ceptions is likely to be learned superficially, recalled only for tests, and then forgotten.

Perhaps practicing teachers' most frequent question about students' prior knowledge is, "How is it possible to assess every student's prior knowledge?" One answer is to use technology to assist with this critical task by allowing students to reveal their preconceptions on well-designed assessments that focus on commonly held misconceptions. Technology tools provide teachers the ability to assess students' misconceptions. Recent applications on handhelds and PCs can be used to aggregate class responses, test knowledge, and provide feedback to the class. Discourse, published by ETS (Educational Testing Service), lets teachers know instantly if each and every student in the class is following the lesson. (***Editor's note:*** For company contact information, see Resources on p. 11.) With instant feedback, instruction can be modified as it occurs for every student. Similarly, Classroom Performance System from eInstruction Corporation provides a nonthreatening environment allowing all students to participate and teachers to give immediate feedback and aggregate results.

Technologies also offer great potential to integrate preconceptions with new knowledge by providing learners with many examples of concepts to be taught from which students can choose the most salient for them. Concept mapping tools enable students to visually see their misconceptions and correct them, leading to increased understanding and retention of content. CTOOLS, from Michigan State University and developed through an NSF grant, provides a Web-based problem-solving environment for exploring concepts in science. WebLearn, developed by the computer science department of RMIT University in Australia, focuses on identifying students' misconceptions in learning college mathematics. If an answer specified is incorrect, commonly occurring misconceptions are checked for and appropriate feedback is provided to the student.

Students benefit because they have the option of choosing examples that are most consistent with their personal backgrounds and knowledge. In addition, an array of examples allows students to test applications of their understandings in different and unfamiliar situations. When students engage their understanding through these examples, they can examine the relationships between their beliefs and outcomes. Students and teachers can develop a stronger sense of the intellectual strategies that may be helpful in developing more extensive and accurate understandings.

Finally, technology-assisted learning tools can provide simulated intellectual challenges through which students can confront the inconsistencies between the knowledge they have and the new knowledge in a lesson. For example, students who misunderstand a concept such as retrograde motion of stars is a product of distance and the earth's rotation rather than the varying speeds of stars can manipulate models of the solar system to see the consequences of varying speed. Students who hold views such as welfare mothers never get off the dole can explore databases with accurate statistical information as well as primary sources. By creating this disequilibrium, teachers can motivate students to learn and focus their attention on critical features of the concept being taught.

Understanding Comes from Knowing Facts and Principles

Understanding evolves from a combination of learning factual knowledge and general principles. Learning factual information is essential, because without facts students have nothing to understand. However, isolated facts are difficult to learn and unlikely to be recalled. Although this may appear obvious, the ways that facts should be connected is often not well understood. The relation between facts, concepts, and principles requires multiple interactions between the learners existing and new facts and more general or higher-level conceptualization that provides a framework for making these facts meaningful.

Students must develop extensive conceptual frameworks to organize

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facts into knowledge in their memories much like a well organized file cabinet makes facts easy to retrieve. When knowledge is extensively connected with other concepts and well organized, it is much more accessible and more accurately used. Organization facilitates applying knowledge in different situations and on novel problems, a process called transfer.

To present the facts and guide students to develop the broad frameworks to organize the facts, teachers must have a strong mastery of the material they are teaching and recognize how students typically learn that material.

Computer-based programs can provide students with a menu of choices from which they can develop experience with varying applications of ideas drawn from examples embedded in multiple contexts. For example, if the goal of instruction was to teach students how the concept of transportation can explain the formation of population centers, students can search maps looking for potential sites based on geographical features. Once sites are selected, the map can reveal where cities actually formed. Students will be challenged to explain both their accurate and inaccurate choices. The SimCity program published by Electronic Arts is one example of software that can leverage the power of technology to facilitate thinking about the accuracy of held beliefs.

A variety of experiences coupled with collaborative discussions enables students to use and organize facts. In addition, as they build experience, students can develop broader conceptions. Finally, technology-based concept maps can show students other ways to organize their understandings and allow them to compare their concept structures. Software that helps learners to brainstorm, organize, plan, and create is valuable for supporting development of concepts. Products, such as Inspiration (Inspiration Software Inc.) and MindMapper (The Bosley Group) graphically present these skills and promote the development of visual learning strategies.

Metacognition Is Essential for Understanding

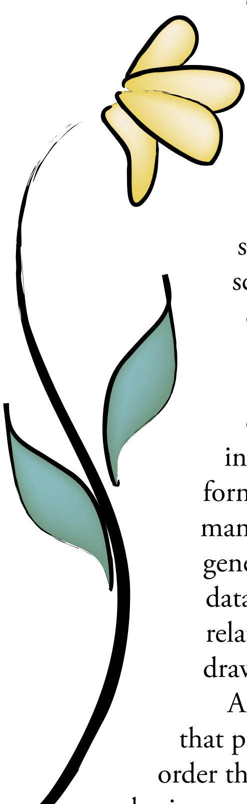
Students must be aware of and control their thinking. Metacognition describes the personal awareness of individuals to choose, monitor, and adjust the thinking strategies they use to learn and solve problems. In other words, students select and control their mental processes so that they can think efficiently and effectively. It is well known that successful learners have more thinking skills and use their intellectual abilities differently than less successful learners.

Genuine understanding is most likely when students are cognitively managing the interaction between what they know and what they are learning. Because learning begins with learners' existing conceptions, growth comes from changing and expanding their existing beliefs. Teachers help students learn to monitor their understanding by using cognitive skills such as reflection and summarizing. In this way, students master the material and the thinking strategies needed to understand. We have developed a site called Study Smart that illustrates how online programs can teach the metacognitive intellectual tools, skills, strategies, and attitudes that are characteristic of successful learners. Many programs integrate these kinds of thinking strategies and provide the opportunity to summarize and reflect on knowledge. Two that effectively engage learners while teaching these skills are the Zoombinis series developed by TERC (distributed by Riverdeep) and BrainCogs developed by Fablevison.

Although metacognition may seem intuitive, developing good metacognitive strategies is difficult for most

learners. The most effective ways to teach these cognitive management skills is to provide many models and continuous opportunities. Teachers are one good source of models, but technologies can also encourage students to address the disequilibrium created by the differences between current and new information.

Simulations and dramatizations of events and situations as well as strategies to solve problems let learners compare, contrast, and experiment with new and old ways of thinking in a variety of settings. For example, in science, a common misconception is that a ball thrown in the air has energy that propels it upward. Using technologies, students can manipulate the variables acting on the ball and compare the outcomes with their predictions. Computer simulations and animations can clearly depict and simulate learning situations and also provide the tools for exploring the concepts through "what if" strategies. The Logal Science Explore Series, published by Riverdeep, includes computer simulations that help students more effectively discover and understand scientific concepts. With the simulations, students develop problem-solving skills as they form hypotheses, manipulate variables, generate and collect data, analyze relationships, and draw conclusions.



Another example that promotes higher-order thinking skills and lasting conceptual understanding is the series of research-based interactive math and science simulations called Gizmos from Explorelearning. These knowledge interactions help students to build stronger understandings and to identify ways to manipulate their cognitive actions to stimulate more active thinking.

Summary

These three findings summarize the basic premise that human learning is a complex interaction between existing understandings and new knowledge. Changing beliefs is often difficult because our inclination is to fit new ideas into existing conceptual frameworks. Information, whether observed or presented by a teacher, that does not fit existing frameworks is usually forgotten because it is either irrelevant or incorrect.

Successfully modifying existing beliefs comes from discovering that a current belief is inadequate to explain new information or as a result of a purposeful quest to expand or to challenge an existing conceptual framework. Although teachers can devise these events for students, it is essential for students to engage personally to change their understandings. And, students who are aware of thinking strategies and are open to new ideas are much more likely to understand in new ways. One of the appeals of technologies is to entice learners to think differently and more expansively.

Technologies can be used to present new knowledge in carefully crafted learning environments that stimulate students to examine their beliefs and revise what and how they think based on new facts and expanded conceptual frameworks.

Because technology is powerful and responsive, it can be used to assess students' existing knowledge so teachers have a clear picture of student needs. In addition, technology-based programs can present students with situations that are inconsistent with their existing conceptions, allowing multiple opportunities to confront misconceptions and to identify and experiment with alternative conceptions.

With the **simulations**, students develop **problem-solving skills** as they form **hypotheses**, **manipulate** variables, **generate** and **collect** data, **analyze** relationships, and **draw** conclusions.

From a pedagogical perspective, teaching involves creating situations in which students can confront their misconceptions, enhance their incomplete knowledge, improve their intellectual abilities, and construct ever more accurate representations of ideas and processes. As they mature as knowers, learners not only build more extensive and accurate understandings but also develop more sophisticated learning skills and strategies. Thus, the twofold general goals of teaching are for students to master content and to develop the skills, strategies, and attitudes characteristic of successful learners. There are many technologies that can be among teachers' pedagogical tools to meet both goals.

Consider your teaching and how you can integrate technology to better teach for understanding. We suggest

you begin by considering your beliefs about teaching and learning. Current thinking about learning indicates that there are substantial differences in the ways we teach if we want the majority of students to learn beyond only recalling facts. Understanding requires a more significant and intense interaction between learners and content so that new ideas are processed deeply and extensively connected to existing and new knowledge. One practical advantage of a well developed and evidence-based theory such as constructivism is that you can make purposeful decisions about using technology in teaching. This is in marked contrast, for example, to using technologies merely because it is possible to expose students to a program or Web site. The benefits of exposure increase markedly when the technology application fits with a purpose consistent with how people learn. Here we have suggested a variety of technology-based applications that are consistent with well developed theoretical propositions to transform classrooms to be more consistent with the conditions that promote learning. In addition, it appears that technologies can be valuable resources for teachers to respond to the increasing demands for students to get passing marks on high stakes tests. Although certainly not magic, technologies can be an important pedagogical tool that increases the ability for teachers to successfully teach all students to learn with understanding.

Resources

Further Reading

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Web Sites

BrainCogs: http://www.fablevision.com

Classroom Performance System: http://www.einstruction.com

CTOOLS: http://ctools.msu.edu

Discourse: http://www.ets.org/discourse/

Gizmos: http://www.explorelearning.com

Inspiration: http://www.inspiration.com

Logal Science Explore: http://www.riverdeep.net/products/logal/

MindMapper: http://www.mindmapperusa.com

Newsbank: http://www.newsbank.com

Proquest: http://www.proquestk12.com

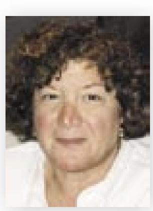
SimCity: http://www.simcity.ea.com

Thomson Gale: http://www.gale.com/schools/

WebLearn: http://weblearn.rmit.edu.au

Zoombinis: http://www.riverdeep.net/products/zoombinis/

Thomas M. Sherman is a professor of education in the College of Liberal Arts and Human Sciences at Virginia Tech. He teaches courses in educational psychology, evaluation, and instructional design and has written more than 100 articles for professional publications. Tom works regularly with practicing teachers and students in the areas of learning improvement and teaching strategies. He is also active in civic affairs, serving on local and state committees.



Dr. Barbara Kurshan is the president of Educorp Consulting Corporation. She has a doctorate in education with an emphasis on computer-based applications. She has written numerous articles and texts and has designed software and networks to meet the needs of learners. She works with investment banking firms and venture groups on companies related to educational technology. She serves on the boards of Fablevision, Headsprout, and Medalis, and is currently on the advisory boards of Pixel, WorldSage, and Tegrity.